

Gravity and Motion



What Determines Gravity?

What Keeps Objects in Orbit?

my planet DiARY

Gravity Assists

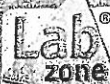
You might think that gravity only brings objects down. But gravity can also speed things up and send them flying! If a space probe comes close to a planet, the planet's gravity changes the probe's path. Engineers plan space missions to take advantage of these "gravity assists." A gravity assist can shorten the probe's interplanetary trip by many years. The diagram shows how the probe Voyager 2 used gravity assists to visit all four outer planets!

Use what you know about gravity to answer this question.

How does a planet's gravity change the path of a space probe?

PLANET DIARY Go to Planet Diary to learn more about gravity.

Path of spacecraft



Do the Inquiry Warm-Up
What Factors Affect Gravity?

What Determines Gravity?

Earth revolves around the sun in an early circular orbit. The moon orbits Earth in the same way. But what keeps Earth and the moon in orbit? Why don't they just fly off into space?


The first person to answer these questions was the English scientist Isaac Newton. In the 1600s, Newton realized that there must be a force acting between Earth and the moon that kept the moon in orbit. A **force** is a push or a pull.

Vocabulary

- force • gravity • law of universal gravitation
- mass • weight • inertia • Newton's first law of motion

Skills

- Reading: Ask Questions
- ▲ Inquiry: Draw Conclusions

Gravity Newton hypothesized that the force that pulls an apple to the ground also pulls the moon toward Earth, keeping it in orbit. This force, called **gravity**, attracts all objects toward each other. Newton's law of **universal gravitation** states that every object in the universe attracts every other object.  The strength of the force of gravity between two objects depends on two factors: the masses of the objects and the distance between them.


Gravity, Mass, and Weight The strength of gravity depends in part on the masses of each of the objects. **Mass** is the amount of matter in an object. Because Earth is so massive, it exerts a much greater force on you than this book does.

The measure of the force of gravity on an object is called **weight**. Mass doesn't change, but an object's weight can change depending on its location. On the moon, you would weigh about one sixth as much as on Earth. This is because the moon has less mass than Earth, so the pull of the moon's gravity on you would also be less.

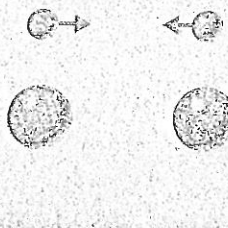
Gravity and Distance Gravity is also affected by the distance between two objects. The force of gravity decreases rapidly as distance increases. If the distance between two objects doubles, the force of gravity decreases to one fourth of its original value.

FIGURE 1

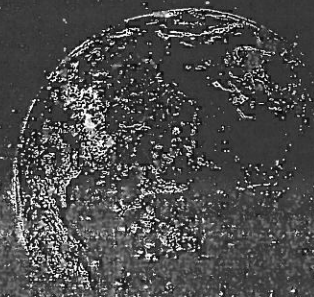
VIRTUAL LAB Gravity, Mass, and Distance

 Compare and Contrast Draw arrows showing the force of gravity in the second and third pictures.

The longer the arrow,
the greater the force.

**did you know?**

You could say we owe our understanding of gravity to disease! In 1665, Isaac Newton was a student. Then a disease called plague shut down the university for 18 months. Newton had to go home. While he was there, he thought of the ideas that led to his theory. (But it may not be true that he got the idea when an apple fell from a tree.)



Do the Quick Lab
What's Doing the Pulling?

Assess Your Understanding

got it?

☐ I get it! Now I know that the force of gravity depends on _____

☐ I need extra help with _____

Go to **my science COACH** online for help with this subject.

What Keeps Objects in Orbit?

If the sun and Earth are constantly pulling on one another because of gravity, why doesn't Earth fall into the sun? Similarly, why doesn't the moon crash into Earth? The fact that such collisions have not occurred shows that there must be another factor at work. That factor is called inertia.

Inertia The tendency of an object to resist a change in motion is inertia. You feel the effects of inertia every day. When you are riding in a car and it stops suddenly, you keep moving forward. If you didn't have a seat belt on, your inertia could cause you to bump into the car's windshield or the seat in front of you. The more mass an object has, the greater its inertia. An object with greater inertia is more difficult to start or stop.

Isaac Newton stated his ideas about inertia as a scientific law. Newton's first law of motion says that an object at rest will stay at rest and an object in motion will stay in motion with a constant speed and direction unless acted on by a force.

Orbital Motion Why do Earth and the moon remain in orbit? Newton concluded that inertia and gravity combine to keep Earth in orbit around the sun and the moon in orbit around Earth. You can see how this occurs in Figure 2.


 **Ask Questions** Before you read the paragraphs under Inertia, write a question you would like to have answered. Look for the answer as you read.

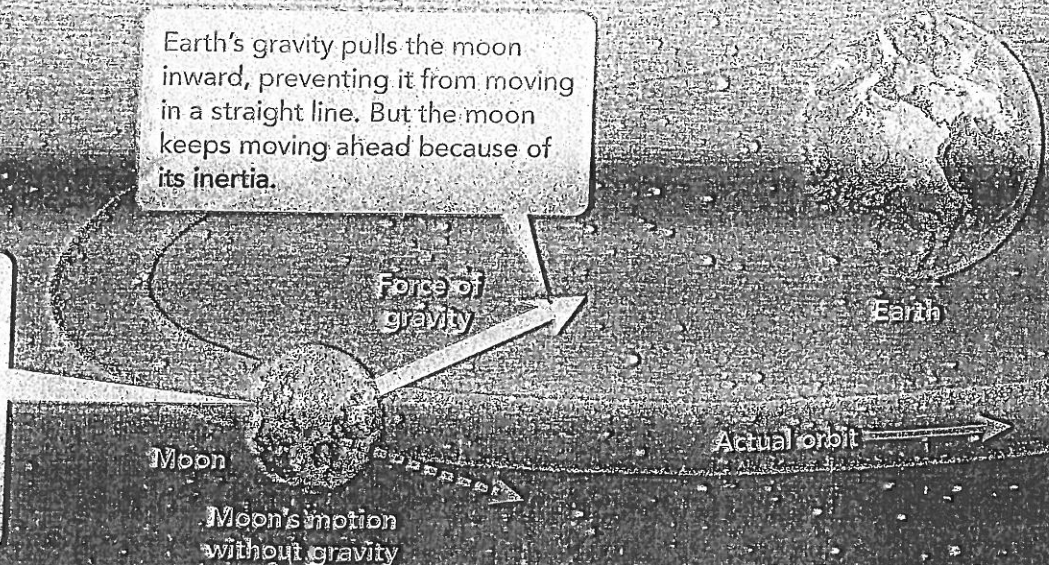
FIGURE 2

Orbital Motion

 How would the moon move if Earth's mass increased?

Earth's gravity pulls the moon inward, preventing it from moving in a straight line. But the moon keeps moving ahead because of its inertia.

Without Earth's gravity, the moon would move off in a straight line. Similarly, Earth orbits the sun because the sun's gravity pulls on it while Earth's inertia keeps it moving ahead.



do the math! Analyzing Data**Gravity Versus Distance**

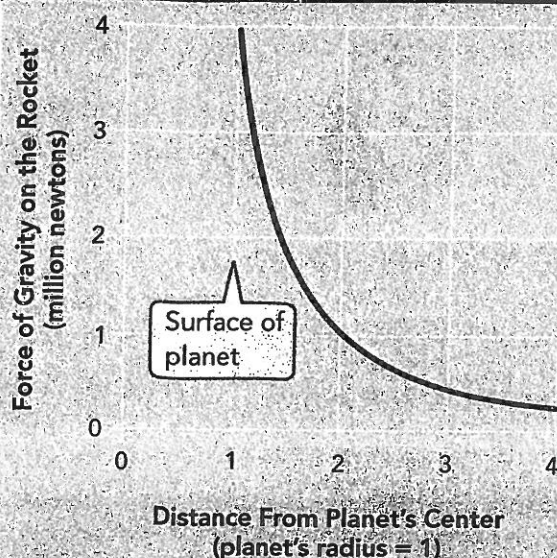
As a rocket leaves a planet's surface, the force of gravity between the rocket and the planet changes. Use the graph to answer the questions below.

1 Read Graphs The variables being graphed are _____
and _____

2 Read Graphs What is the force of gravity on the rocket at the planet's surface?

3 Read Graphs What is the force of gravity on the rocket at two units (twice the planet's radius from its center)?

4 Make Generalizations In general, how does the force of gravity on the rocket change as its distance from the planet increases?

Gravity and Distance**Assess Your Understanding**

1a. **Identify** What two factors keep a planet in orbit around the sun?

b. **Draw Conclusions** What keeps Earth from falling into the sun?

c. **CHALLENGE** How would a planet move if the sun suddenly disappeared? Explain.

got it?

☐ I get it! Now I know that objects are kept in orbit by _____

☐ I need extra help with _____

Go to **my science COACH** online for help with this subject.



Do the Quick Lab Around
and Around We Go.